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BACTERIOLOGY AND THE WAR¹

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THERE are so many aspects of this problem that it is somewhat difficult to determine where to begin and what to discuss. The war is so vast in its influence and bacteriology is so extensive in its scope that naturally they come into contact at many points. It shall not be my purpose, though it would be quite to the point, to discuss the great fields of agricultural bacteriology, industrial bacteriology, plant bacteriology and veterinary bacteriology. These all have a more or less intimate relationship with the war. I shall limit myself to that phase of the subject that concerns the prevention and cure of human affliction.

Nor shall I condescend to discuss the possible uses that deadly disease-producing germs may be put to in the willful destruction of human or animal life, highly suggestive reports of which have recently come to our attention. Even in war such practises are so repellent to every sense of honor and fair play that it is difficult to believe them in this twentieth century of Christian civilization.

The relation of bacteriology and war is a reciprocal one. While the study of bacteria has most fundamentally affected the success and the methods of procedure in military campaigns, in turn, there is presented to the bacteriologist for solution many new problems of vital interest to the science. Not only are new fields for investigation opened up by the war, but military organization furnishes opportunities for observation and confirmation of existing data on a scale and under conditions not usually possible in civil life.

During the war, the destruction of life by disease-producing germs often, indeed usually in the past, has far exceeded the

¹ Address delivered at the Opening Exercises of the University of Illinois, College of Medicine, Chicago, October 4, 1917.

destruction of life by bullets. We have only to point to the Spanish-American War less than twenty years ago to appreciate the truth of this statement. We may naturally anticipate therefore that in the present world war, the rôle that these minute creatures play will be one of first importance.

War, and especially the present war, involves the congregating and mingling of great bodies of men, frequently from distant parts of the world. This means the transportation of human and animal parasites along with the hosts. This transportation of parasitic varieties of animal or plant life we have long known to be a dangerous process. As examples, we may mention the Mexican cotton-boll weevil, the gipsy moth, and the foot and mouth virus. The bestowal by the white man upon the Indian of tuberculosis, syphilis, measles and smallpox along with culture and enlightenment has nearly cost the latter his existence as a race. In general, parasites transported to a new soil commonly increase their ravages enormously. This is one of the phenomena observed in connection with this war, examples of which will be cited presently.

The ravages of disease germs in the army may not be the most serious phase of this problem. The return of the troops to their homes—of the wounded during the war, and the entire army after the war—must lead to a more general infection of the civil population with the various diseases that commonly follow the military camps.

I shall now refer rather briefly to certain infectious, bacterial diseases which may serve to illustrate some of the more important advances for which the war, to some degree at least, is responsible. In general this progress naturally centers round studies dealing with the etiology and specific therapy of these infections.

Trench Fever.—An unusually interesting disease has made its appearance especially on the west front, to which the term trench fever has been given. This appeared shortly after the beginning of the war and was first definitely recognized and carefully described by Rankin in 1915. It has occurred especially in Flanders, France and England; also in Mesopotamia, the Balkans, Saloniki, among the Austrian and German troops on the eastern front and in the Tyrol.

Trench fever is not a good name, for it is known to occur in England and attacks often many persons who have never been to the trenches. It occurs virtually in epidemic form, thousands of persons at times rapidly coming down with the infection. It is different from any hitherto known disease. It is a definite clinical entity and is no doubt infectious in nature.

There is a typical fever curve, often relapsing in character, intense and constant shin pains, persisting often for months, and an increase in the mononuclear leucocytes, the total count usually being, in the febrile stage, 14,000 to 16,000. One attack does not confer immunity. It is never fatal, but causes often great suffering and distress and interferes seriously with the efficiency of the troops. No doubt our American troops in France will soon be infected, since it appears to be highly contagious.

The cause of the disease is entirely unknown, as is also its mode of transmission. Experiments on volunteers indicate that the disease can be reproduced by injecting blood from a patient into well persons and also that the virus resides in the blood corpuscles and not in the serum. Thus far no visible parasite has been detected in the blood. Trench fever has been less troublesome in the troops who have had good bathing facilities and who have in general been cleanest. Active campaigns against lice seem to have lessened the incidence of the disease. Captain Urquhard acquired the short form of the disease after permitting lice from a patient suffering with this disease to bite him. Lice are so common under present war conditions that practically every one is infested, and hence a history of pediculosis means little in determining transmission. At present it is not surely known whether or not lice are the usual or the natural agents in the transmission of this disease; they are, however, under strong suspicion.

One naturally asks whence comes such a disease. So far as we know it is an entirely new infection. Did it arise *de novo* as it were, by a sudden appearance of a mutant from some related virus? The discovery of its etiology may throw light on this problem, but as yet all attempts to find its cause have failed. Possibly this infection has existed unrecognized in some remote corner of the world and by the mobilization of various races in this world war it has found conditions suitable for its rapid spread.

Infectious organisms, no doubt, originate as do other species, but bacteriologists as yet have never observed an infectious disease arise. Is the disease of trench fever an instance of such a new infection? If this should be the case it might furnish a unique opportunity for the study of the ultimate origin of a disease. And after this trench warfare is over and the troops have scattered again to the corners of the earth, what will be the fate of this new disease? We shall watch this phenomenon with interest.

Infectious Jaundice.—Infectious jaundice appears to be a

common disease often occurring more or less in epidemic form. The cause of the jaundice seems to be varied. A certain proportion of the cases are no doubt intestinal in origin and caused by organisms of the paratyphoid group.

But another infection has been recognized which is now known to certainly cause a very considerable number of these icteric cases. It is commonly referred to as Weil's disease. This disease is not new, having been observed in previous wars; possibly it was responsible for many of the 70,000 cases of jaundice which occurred in our Civil War. It is characterized by intense muscular pains, high fever for several days, followed by jaundice and nephritic changes in the urine. Often intense hemorrhages under the skin and from the nose occur.

This disease is caused by a spirochete, the *Spirocheta ictero-hemorrhagiae*, which has now been repeatedly found in the various fluids and organs of the infected persons. It appears especially in large numbers in the kidneys and urine, as well as in the liver of the host. Most interesting are the observations recently made, particularly by Japanese investigators, that this germ commonly infects the wild rat, which may harbor it for a long time without special harm to itself. The kidneys of the rat likewise contain large numbers of the spirochetes and they are thrown out in the urine of the animal to infect the soil, and especially the water. Trenches would therefore furnish an excellent place for the dissemination of this disease. From the soil and water the organisms find their way into the human body both through the skin of the feet and into the intestinal canal. This disease has now been recognized along the entire western front. It is rarer in Belgium and France, but appears to be quite common along the Italian line. It prevails in the German armies and has attacked the British soldiers at Saloniki. In Japan the disease exists in a highly virulent form, especially among miners and rice planters who go barefoot. Work so far done along therapeutic and immunologic lines gives promise of success, but it is early as yet to make definite assertions on these points.

This disease is another example of an important human infection transmitted largely if not entirely by a lower animal and is also another severe indictment against that king of pests, the wild rat. Recently Noguchi has found this same spirochete in the kidneys of wild rats in New York city. Its dissemination probably has been quite general though not in large numbers. No doubt the war will tend to spread the disease still further and probably to cause a more universal infection of rats with the specific germ.

Trench Nephritis.—Trench nephritis is an exceedingly common disease on the various fronts, and, though much work has been done with the view of determining its cause, the real nature of the malady remains obscure. It manifests itself as an acute process and certain features of the disease suggest its possible infectious nature. Some of the cases at least may be infections with the spirochete of Weil's disease. Pathologically and clinically the disease closely resembles the form of nephritis seen following colds, scarlet fever, etc. No specific microbe has as yet been isolated and attempts to transmit the disease have failed.

Cerebrospinal Fever.—Cerebrospinal fever has long been known to be an army disease, though now it has come to be a serious menace in both peace and war times. It appears to affect soldiers living in camps, barracks, towns, etc., rather more than those engaged in an active campaign. During the present war it has occurred particularly in England, and early attacked especially the Canadian troops when quartered in that country. The disease during the past season broke out in several of our recruiting camps. As the summer advanced, the disease gradually subsided; excepting an occasional focus, there is little at the present time. However, unless radical measures are taken next winter and spring, we may predict to almost a certainty a recurrence of serious outbreaks of this highly dangerous malady.

Its cause, the meningococcus, finds its normal habitat in the nose and throat of human beings. Now and then it passes through the mucous membranes into the blood and lymph streams, finding its way into the region of the brain, especially the meninges, where it grows and produces an acute inflammation. By no means do all who harbor the germs in their nasopharynx develop the disease, but such "carriers" serve as dangerous reservoirs for the dissemination of the bacteria to others who may be susceptible. Naturally then the campaign against this infection consists in the proper treatment of "carriers," both healthy and sick, as well as in the curative treatment of those ill with the disease.

The war has furnished and is furnishing an excellent opportunity for a severe test on a large scale of methods of control and treatment which had been devised largely before the war. With reference to the serum treatment of the disease, perfected several years ago in the United States by Flexner, a large body of data tended to show the undoubted value of the intraspinal injection of serum as manufactured by the Rockefeller Institute. Some time before the war this institution

ceased making the serum, turning this work over to various public health and commercial laboratories.

In the winter of 1914-15 on the continent, especially in England, many cases of meningitis developed in both the civil and military population. Though the patients were promptly given the serum that was available, the death rate continued abnormally high, ranging 50 to 60 per cent. or even higher. The death rate in earlier epidemics in this country, when the Rockefeller serum was used, had been from 20 to 30 per cent. On investigation it was found that the trouble no doubt lay in the poor quality of the serum available at the beginning of the war. Since then the Rockefeller Institute has resumed its manufacture of the serum and other reliable laboratories here and abroad have also taken up the work with the result that during the past year the mortality of this disease in Europe and also in the United States Army compares with the earlier data, that is, 20 to 30 per cent. mortality. The serum should be made by the injection into horses of several strains of meningococcus, it being now definitely recognized that there exist a number of groups of these germs differing at least to some degree, especially in their immunologic properties.

As to the "carriers," especially those who are healthy or who show no definite symptoms of meningitis, considerable progress has been made in their management. The healthy "carrier" is more dangerous than the person ill with the disease. They outnumber the latter 10 to 30, or more, to one. Any individual coming into intimate contact with a meningitis patient is practically sure to become a "carrier." A nurse or a mother tending her sick child is certain sooner or later to contain the meningococcus in her naso-pharynx. The recognition of such persons is made possible by wholesale culturing on suitable media of entire bodies of troops and others coming in contact with them, and those harboring the germs are isolated and treated. The treatment is various. The germs may disappear in time without any special therapy. Often they are very persistent and resist most vigorous treatment. Tonsilectomy has been resorted to with little success. Encouraging results have been obtained by the vigorous use of nasal and throat sprays. For this purpose various antiseptics have been tried, but those most efficient seem to be 2 per cent. chloramin-T and zinc sulphate, 1.2 per cent. in watery solution.

It is to be emphasized that there is a real and serious danger from this highly fatal disease in the mobilization of troops from various parts of the country. However, we now know enough to quite successfully cope with it, provided we apply

what we know. The successful preventive measures include a careful survey of localities from which the men come with reference to meningitis, a systematic search for "carriers" and their retention until free from meningococcus; early diagnosis and isolation with repeated intraspinal injections of a reliable serum. To keep the disease out of a camp, every soldier should be examined for meningococci before he is allowed to enter the barracks.

Typhoid Fever.—Were one discussing this subject of infectious disease in almost any other war in history, the larger part of the time would be devoted to intestinal infections, especially typhoid fever. In this war, thanks largely to protective vaccination, the so-called enteric fevers have ceased to be a serious problem. Our knowledge of the dissemination of typhoid through carriers and of the methods for their detection is also a most important phase of the control of this disease.

The development of the use of vaccines in this disease during the last fifteen years must be counted as one of the great medical achievements of the age, and ranks beside Jenner's discovery of smallpox vaccination. This procedure used in the United States Army and elsewhere before the war and now submitted to the crucial test of protecting the huge armies in this war under most varied and critical circumstances has now, it would seem, demonstrated its value in a way which should convince the most skeptical. What further proof is necessary to show that now typhoid fever or at least a large part of it in our country and elsewhere is entirely unnecessary. The problem has been solved from the standpoint of scientific medicine. It is now a public health and social problem. In other words it is squarely "up to the people" as to whether or not they wish to use what the contributions of medical science have given them.

Paratyphoid fever, a disease simulating typhoid, but less fatal, has been a serious infection in certain regions. This was largely because proper vaccination was not resorted to, for example, in the Gallipoli campaign. The experience of the war, however, has confirmed the results, obtained on a limited scale before the war, that vaccination with paratyphoid bacilli is as efficacious in preventing this disease as is the procedure in typhoid fever. Often vaccines are administered composed of mixtures of typhoid bacilli and paratyphoid, A and B, and in the eastern front, the cholera bacillus is also added. The injection of mixtures of these varieties of dead bacteria has been found to immunize satisfactorily and saves much time.

Asiatic Cholera.—Asiatic cholera naturally has, in the east

where it is more or less endemic, been responsible for many cases of sickness, but great epidemics have not developed. The problem here is almost identical with that of typhoid and paratyphoid fevers. Vaccination with dead or treated cholera vibrios, the detection of "carriers," and proper control of water and food supplies are the procedures which will make Asiatic cholera as little feared by the soldiers as is smallpox.

The *Dysenteries* are in a less satisfactory state than the typhoid fevers. Especially in the eastern and Mediterranean campaigns both amebic and bacillary types of the disease have been very prevalent. No serious outbreaks have occurred on the western front. Extensive and valuable studies, especially of the protozoal varieties, have been made by the Medical Research Committee of Britain and our knowledge of them has been greatly extended. Vaccination has not proved of great value in this disease, probably because of the high toxicity of the bodies of the bacilli. The problem of "carriers" is here paramount and through proper hygienic precautions satisfactory progress is being made in the control of this disease. In amebic dysentery we have a very effective therapeutic agent, emetine, the favorable results obtained heretofore having been abundantly confirmed on an extensive scale in the military camps of the Mediterranean countries. Emetine given subcutaneously, while practically curing the disease, does not sterilize the intestinal canal and such individuals often become chronic "carriers" of amebæ. Dale and others have used a new compound, emetine bismuth iodide, by the mouth and have found it more effective in completely sterilizing the patient of his amebæ. Oral administration is therefore likely to supplant the hypodermic use of emetine in this infection.

Wound Infections.—Wound infections of all kinds have of course appeared in this war on a scale never before met with in the history of medicine. With these the bacteriologist and the surgeon have contended valiantly and on the whole hopeful progress has been achieved. The nature of the warfare makes primary disinfection of the wounds usually impossible and often suppuration is well advanced before the patient reaches the surgeon. The pyogenic cocci, fecal bacteria and especially the anaerobes are the chief offending organisms.

In the management of these cases, the medical men have, as it were, arranged themselves into two schools. First, those who rely chiefly upon the physiological mechanisms in the body to combat and resist the invading germs and, second, those who depend on the application from without of antiseptic substances to kill or prevent development of germ life.

Sir A. E. Wright, known to the world for his studies in pathology, especially in phagocytosis, has well been called "the apostle of physiological methods." Wright, during this war and close to the front, has done splendid work in the field of surgical bacteriology. He has devised methods for drawing into the infected areas the fluids of the body containing the protective substances normally found there. For this purpose he has used strong solutions of salt, often indeed packing the wound with solid salt for a time, in order to stimulate the free flow of lymph to the area. He has also devoted much time to the continuous irrigation of wounds with hypertonic salt solutions and good results have been reported from this method.

Hopeful progress may also be reported in the field of antiseptic surgery. The ideal antiseptic of course is one which will kill the microbes and not injure the body tissues. The older methods of the application of powerful germicides, destructive of tissues as well as germs, have been largely superseded by the application of more specific substances. This work has centered largely around chlorine compounds. The work of Dr. Dakin and Dr. Carrel, the well-known investigators from the Rockefeller Institute, has resulted in the use of a special technique for the continuous irrigation of wounds with a modified hypochlorous solution. This treatment, according to many surgeons, has led to marvelous results, reducing the bacterial content of wounds to the point where often early closure is possible. This method has become very popular with surgeons, especially at the front, and is, according to many, the best method yet devised in dealing with suppurating wounds.

Dr. Dakin has extended his work by showing that the chlorine from the hypochlorites combines with proteins in such a way as to form substances known as chloramines. These bodies, though possessing a high germicidal value, seem to be quite non-toxic and have no action on albumen. A certain preparation known as chloramin-T has come into very general use, especially in mouth infections, in saturating gauze for antiseptic purposes and as a most efficient throat spray in the treatment of meningococcus carriers.

Another antiseptic that deserves mention is a benzol derivative known as flavine. This was originally prepared in Ehrlich's laboratory some years ago for the treatment of trypanosomiasis. Recently the bactericidal power of this substance has been carefully studied in England by several investigators who find that it is an active and efficient antiseptic without possessing harmful effect on phagocytosis or on tissues

generally. Furthermore, its antiseptic action is actually enhanced in the presence of serum rather than diminished, as is the case with practically all other antiseptics known. It is quite non-irritant and can be used in continuous irrigation after the method of Carrel or in conjunction with the salt pack method of Wright. Brilliant green, another benzol derivative, has been found to possess similar properties and is even more highly germicidal, though it acts less efficiently in serum. Sufficient time has not elapsed nor have these substances been available in sufficient quantities for the thorough and crucial tests necessary to establish them on an absolutely permanent basis as surgical antiseptics. The report of the Medical Research Committee of the British Government on these substances, however, is highly favorable. It is to be noted that these substances are of such a nature that it is possible to combine the methods of the two schools mentioned above, the physiological and the antiseptic, and thus bring the advantages of both into play against microbic invasion of the tissues.

Tetanus.—Lockjaw or tetanus is an anaerobic infection primarily of wounds long feared by the military surgeon. In the early part of the war, especially during the battle of the Marne, when inadequate medical supplies prevented the use of serum, many cases of lockjaw developed. Later, protective inoculation of tetanus antitoxin was administered promptly to every wounded soldier as soon as possible after leaving the firing line and the results have been most gratifying. In the British Army in October of 1914 the ratio of cases of tetanus to wounded men was 32 per 1,000. In November of that year following the introduction of universal immunization of the wounded the ratio fell to 2 per 1,000, at which point and even lower it has continued to the present. Not only has the number of cases been very greatly reduced, but the serum has markedly modified the course of the infections that do occur.

Local tetanus as opposed to generalized disease is recognized as a phenomenon of partial protection. Cases of delayed, late and post-operative tetanus have been carefully studied. Tetanus spores apparently may lie in the tissues for long periods little affected by the antitoxin and later through an operation or trauma may resume their development. Therefore repeated prophylactic inoculations under certain conditions seem essential, especially before surgical procedures. The danger of anaphylaxis is practically negligible.

Curative treatment of the disease by the antitoxin can not be regarded as satisfactory. The intra-spinal injection of the serum is practised, and there is some evidence to indicate its

efficacy, especially when given early. But its curative value does not compare with its protective value.

This data—and the above statements are based on an enormous number of cases—is not new. In general it agrees entirely with what we knew before the war of the value of antitetanic serum. But the war has furnished an opportunity for testing the serum on a scale never before possible and the results have convinced many who previously were skeptical of its value. Before leaving the subject I can not refrain from directing your attention to the enormous number of soldiers saved by this one simple procedure—a procedure, I may say, based upon and made possible by the application of scientific bacteriologic principles.

Gas Gangrene.—Another wound infection caused by an anaerobic bacillus, and quite commonly observed in deep wounds of the muscles, is gas gangrene. The infecting agent is a spore-bearing bacillus, the *Bacillus Welchii*, a common inhabitant of the intestinal canal, clothing and particularly of contaminated soil. Soldiers engaged in trench warfare, and especially those receiving deep lacerating wounds with shrapnel, in which dirt and soiled clothing are carried into the flesh, mostly suffer with this type of infection. The bacillus grows particularly well in muscle tissue, producing an inflammable gas which penetrates tissues where it can easily be detected by the characteristic crepitus.

This infection complicating wounds is extremely serious and nearly always results fatally. The organism appears to produce a highly toxic substance, the real nature of which has not yet been determined with certainty. The prevalence and the seriousness of this infection to the surgeon has stimulated considerable work on the nature of the toxins secreted. Of first importance is the recent work of Bull and Pritchett² of the Rockefeller Institute, who believe they have discovered a soluble toxin produced by the bacillus when grown in media containing a small amount of sugar. By injecting the toxin into animals, they claim they have produced an antitoxin which is effective in neutralizing the poison, and animal experiments indicate a definite protective action of the antitoxic serum against the toxin.

Reports of the action of the antitoxin in human cases are not as yet available. Naturally work of this kind needs confirmation before it can be accepted. Repetition of Bull's experiments are going on in various laboratories and we shall

² THE SCIENTIFIC MONTHLY, October, 1916, p. 310.

soon know the results. The importance of this work, if confirmed, will compare with that of the discovery of tetanus antitoxin.

Typhus Fever.—The brilliant work of American investigators, especially Ricketts on typhus fever in Mexico a few years before the war, was done at an opportune time. It was then shown clearly that typhus fever is transmitted by the body louse and in all probability only in this way. This fact at once determined the method of attack, and it was soon shown that the disease could be absolutely controlled by the extermination of this parasite. Consequently, when typhus fever early in the war broke out on the eastern front, especially in Servia, medical science was at hand with the proper knowledge of how to control this plague. The excellent work of the American Commission under Dr. Strong in Servia, aided by well-organized British units, is well known to the world. By the elimination of lice, it was possible in a relatively short time to bring the epidemic under complete control.

The etiological agent of this disease has not with certainty been determined. Plotz and his associates in New York believe the agent to be a bacillus which they have isolated from the blood and organs of patients suffering with the disease. They report specific immune reactions with this organism and certain suggestive animal experiments. However, entirely different organisms have been described as etiological agents by other workers. Further work must decide what the true causal organism may be.

This disease has not appeared on the western front and is not likely to. Our American troops are therefore in no danger from this infection. The disease is now known to occur in a mild form in this country, particularly in New York City and in all probability cases have even been observed recently here in Chicago.

Other diseases of a bacterial nature might be briefly referred to, chiefly because of the necessity to cope with them in connection with the military organization of countries. The tubercle bacillus is in many countries, but especially in Belgium and France, decidedly increasing its ravages over peace times. This is due to a number of causes, but chiefly to the poor and inadequate food supply and to exposure. The venereal problem, as usual in wartime, presents itself in formidable proportions. Almost drastic measures have been instituted by the countries in their efforts to cope with these diseases. Germany has enacted stringent laws applicable to soldiers and especially to those who are now discharged and to those discharged at the

end of the war. The radical laws already in effect in Australia with the view to regulate the venereal peril will be watched with interest by all students of hygiene and preventive medicine.

Pneumonia and rheumatic fever in the armies in Europe, strange as it may seem, have not, according to all reports, appreciably increased their incidence over that met with in the civil population. Poliomyelitis has not as yet menaced the military camps.

The above-mentioned diseases discussed in this rather brief way furnish some idea of the more important specific advances that have been going on during the war in the field of bacteriology. In general, it may be said that these advances cover fairly well the entire field of this science so far as it is related to pathogenic bacteria.

Influences of a less specific character are resulting from the war, especially along the lines of general medical research and also in the education of the people in hygienic matters.

The admixture of medical men from various countries brought on by the war, all of whom are necessarily interested in bacteriological problems, has resulted and will result in a most desirable and profitable exchange of ideas, from which we may reasonably expect further valuable contributions to the science.

The education of not only medical men but of the common soldier in military hygiene will in itself be a great stimulus to the science of bacteriology, since military hygiene is so largely based on bacteriologic principles. The instruction now given to the soldiers by lectures and in other ways will make them more intelligent about such matters in general and no doubt will result in an increased interest in this subject by the common people.

The value derived from the physical examination, the military training, the careful supervision exercised in the army over the general health and hygienic environment of the soldier will be of first importance in raising the resistance of the men to the invasion of bacteria of various kinds. The proper control of liquor in itself will accomplish much in reducing the incidence of several bacterial diseases now dependent largely upon the abuse of alcohol.

A most important problem from the standpoint of infections is the proper care of the teeth. Never before has so much attention been given to the hygiene of the mouths of the soldiers and to instruction of the men on this subject. This should eliminate many serious infections about the mouth, jaws and

face, and it will no doubt educate the entire people along a line heretofore sadly neglected. This interest in dental bacteriology in the army is largely due, no doubt, to the progress made in recent years especially in the United States and England in the study of focal infections about the mouth and teeth and the dissemination of such infections to other regions of the body.

I consider it entirely proper here to call attention to the very important rôle that American bacteriology and hygiene has played in this great war. Not only the work done since the beginning of the war but that done before the war has had a most significant application to the great medical problems at hand. The work of Flexner and his associates of Rockefeller Institute on meningitis, the investigations of Reed, Carroll, Lazear and Agramonte, on the control of yellow fever in Cuba, the work of Gorgas in making a health resort of the disease-infested Panama Zone, the work of Carrel, Dakin and a number of other brilliant American surgeons on wound infections and their treatment, the researches of Flexner, Noguchi, Mathers, Rosenow and others on poliomyelitis, the work of Ricketts, Wilder, Anderson, Goldberger and other Americans on the etiology and transmission of typhus and the remarkably prompt and efficient control of the Servian epidemic of typhus by Dr. Strong and associates, the promising studies of Bull and Pritchett on gas gangrene, all these constitute a series of contributions which, from a military point of view, are fundamental in the conduct of a great war. Already we may say American medical science has carried on its side of the military campaign and has set a mark for preparedness which might well excite the admiration of, and indeed furnish a lesson to, the other departments of our military organization.

And finally let me say that while no doubt in a relatively short time this great war among nations will cease, the great war against the countless hordes of disease-producing germs will go on for ages yet to come. This war of man against disease is in every sense a real contest, in which there are pitted against each other mechanisms far more intricate and complicated than have yet been devised by man in the European War. While the contest between man and man may be more spectacular and may involve greater destruction in mass, the assault by the microbes is far more insidious, more elusive, and on the whole far more deadly. Indeed war is in a sense simply an incident which man foolishly permits to enter into that greater struggle with germ life and which often gives the upper hand to the latter. The great armies of men, women and children that are destroyed every year by bacterial diseases make

the destruction of life in Europe seem almost trivial. We speak of this war resulting in the loss and maiming of twenty million lives. Bubonic plague, the black death, five centuries ago in one epidemic in Europe killed twenty-five million persons. One might point to the army of 150,000 in the United States alone carried off each year by the tubercle bacillus, another 150,000 destroyed by the pneumococcus, 25,000 by the typhoid bacillus, several thousand more by smallpox virus and so on. What a pity some of the energy, time and money spent in the great war could not be spent in combating the deadly microbe. A combined attack against several of our great diseases, such as the nations are making against each other, would no doubt result in their extinction. Yellow fever is limited to certain well-defined areas and an allied attack on the several endemic foci would probably exterminate it. Bubonic plague, when not on an epidemic rampage, is localized in three or four well-defined regions of the world. A concerted attack by various nations, using all the modern weapons of microbic warfare, would almost certainly annihilate that triple alliance between the plague bacillus, the rat and the flea, upon which the disease depends for its existence. Asiatic cholera would probably be vulnerable to a well-directed assault. For the existence of several well-known germ diseases, like smallpox and hydrophobia, there is no excuse excepting the stupidity and ignorance of the people. It has been said that we are twenty-five years behind the times so far as the actual application of scientific and laboratory medicine to the control of infections is concerned. In general this is true. For certain diseases like smallpox we are far more than twenty-five years behind the times. We know enough about several of our diseases and have for years known enough to render them extinct. But we do not yet know how to execute this knowledge and to make it bear fruit as it should. This is not primarily a bacteriological or medical problem, but a social one. Indeed it is one of the great problems of democracy.